

What is Claimed is:

1. A method of manufacturing a light-propagating probe for a near-field microscope, made from a light-propagating body having a transparent opening for passing light at an end section and a metal film coat at a tip section other than at the transparent opening, the transparent opening being formed so as to give a pointed tip section, having a hook-shape close to the tip section and functioning as a cantilever having resilience capable of being displaced in a direction perpendicular to a sample surface, and having a reflecting surface for carrying out optical position detection of the tip section at an opposite side to the tip section with respect to the hook-shaped section, comprising:

a step of sharpening the light-propagating probe body;

a step of forming the light-propagating probe body in a hook-shape;

a step of forming the reflecting surface;

a metal film coating step for forming the transparent opening section;

a step of protecting the transparent opening section with a resist material;

a step for metal film coating a spring operating part to the rear from the hook-shaped section; and

a step of removing the resist material.

2. The method of manufacturing a light-propagating probe for

a near-field microscope as disclosed in claim 1, wherein principal steps are carried out in the order of:

- a step of sharpening the light-propagating probe body;

- a step of forming the light-propagating probe body in a hook-shaped;

- a metal film coating step for forming the transparent opening section;

- a step of protecting the transparent opening section with a resist material;

- a step of forming the reflecting surface;

- a step for metal film coating a spring operating part to the rear from the hook-shaped section; and

- a step of removing the resist material.

3. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein principal processes are executed in the order of:

- a step of sharpening the light-propagating probe body;

- a step of forming the light-propagating probe body into a hook-shape;

- a metal film coating step for forming the transparent opening section;

- a step of forming the reflecting surface;

- a step of protecting the transparent opening section with a resist material;

a step for metal film coating a spring operating part rearwards from the hook-shaped section; and

a step of removing the resist material.

4. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein principal processes are executed in the order of:

a step of sharpening the light-propagating probe body;

a step of forming the light-propagating probe body into a hook-shape;

a step of forming the reflecting surface;

a metal film coating step for forming the transparent opening section;

a step of protecting the transparent opening section with a resist material;

a step for metal film coating a spring operating part rearwards from the hook-shaped section; and

a step of removing the resist material.

5. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the step of sharpening the light-propagating probe body includes a procedure for applying a tension to the light-propagating probe using a pair of spring mechanisms, irradiating carbon dioxide gas laser light by focusing with a lens, and, after locally heating the

light-propagating probe to cause tension fractures, reshaping the tip section using wet chemical etching.

6. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 5, wherein the pair of spring mechanisms are independently adjustable spring mechanisms, further comprising a procedure for independently adjusting respective spring constants or initial tension.

7. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 5, wherein the lens for focusing the carbon dioxide gas laser light is a cylindrical lens, and further including a procedure for focusing the carbon dioxide gas laser light in a direction where a line focal point crosses the light-propagating body, and adjusting the position of the light-propagating body to the focal point or in front of or behind the focal point.

8. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 5, wherein the lens for focusing the carbon dioxide gas laser light is a spherical lens, and further including a procedure for focusing the carbon dioxide gas laser light, and adjusting the position of the light-propagating body to the focal point of in front of or behind the focal point.

9. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 5, further including a procedure for, after the carbon dioxide gas laser light has been irradiated at a comparatively small output such that the light-propagating body displays slight stretching until the light-propagating body stretches a specified amount, increasing output to cause fracture.

10. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 9, wherein, in the procedure for increasing the output to cause fracture, the output of the carbon dioxide gas laser is increased at a fixed rate.

11. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 5, wherein the step of irradiating the carbon dioxide gas laser light to cause tensile fracture of the light-propagating body is simultaneously observed using a camera, and confirms an optical axis and monitors stretching state of the light-propagating body.

12. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 5, wherein the wet chemical etching includes a step of immersing the light-propagating body that has been subjected to tensile fracture in an etching fluid mainly comprising hydrofluoric acid to further

sharpen the tip section.

13. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 5, wherein the wet chemical etching includes a step of immersing the light-propagating body that has been subjected to tensile fracture in an etching fluid that comprises a first solution layer mainly comprising hydrofluoric acid, and a second solution layer having a lower specific gravity than the first solution layer, and not reacting or mixing with the first solution layer, to further sharpen the tip section.

14. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 12, wherein the etching solution is temperature controlled to a fixed temperature.

15. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 13, wherein the wet chemical etching includes a step of washing the light-propagating body using an organic solvent that dissolves the material constituting the second solution layer, and is water soluble.

16. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the

step of sharpening the light-propagating body includes a procedure of immersing the light-propagating body in an etching fluid that comprises a first solution layer mainly comprising hydrofluoric acid, and a second solution layer having a lower specific gravity than the first solution layer, and not reacting or mixing with the first solution layer.

17. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 16, wherein the etching fluid comprising a first solution layer and a second solution layer, and the light-propagating body, are arranged on a vibration isolation table, and the etching solution is temperature-controlled to a fixed temperature.

18. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 16, wherein a process of sharpening the light-propagating body includes a step of washing the light-propagating body using an organic solvent that dissolves the material constituting the second solution layer, and is water soluble.

19. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the step of sharpening the light-propagating body includes a step of testing for presence or absence of cylindrical cavity defects within

the light-propagating body.

20. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 19, wherein the testing step for presence or absence of cavity defects includes a procedure for arranging the light-propagating body between two light transparent glass plates, filing between the two glass plates with a transparent fluid medium having the same refractive index as the refractive index of the light-propagating body, and then observing the light-propagating body using an optical microscope

21. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 20, wherein the observation of the light-propagating body using the optical microscope in the step of testing for the cavity defects is carried out using dark field observation.

22. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the step for making the light-propagating body in a hook shape is a step of irradiating carbon dioxide gas laser light to a desired position close to a tip section of the sharpened light-propagating body.

23. The method of manufacturing a light-propagating probe

for a near-field microscope as disclosed in claim 22, wherein the step of forming this light-propagating body in a hook shape is a step of determining the bend angle of the hook shape through simultaneous observation using a camera, to control irradiation of the carbon dioxide gas laser light.

24. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the step of forming the reflecting surface has a step of sharpening the light-propagating body, a step of forming the light-propagating body in a hook shape, and a step of mechanically polishing the hook-shaped section of the light-propagating body sharpened and formed in a hook shape that is opposite to the tip section by pressing against a rotating polishing plate, the pressing being carried out utilizing resilience of the light-propagating body itself.

25. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 24, wherein the step of mechanically polishing the light-propagating body contains a procedure for causing the light-propagating body to project a specified length and fixing to a polishing stage at a first angle with respect to a surface of the polishing plate, bringing the polishing stage and the polishing plate relatively close to each other, causing a part of the light-propagating body to be polished into contact with the polishing plate, bringing the polishing stage

and the polishing plate closer together relatively, and holding the part of the light-propagating body to be polished at a second angle with respect to the surface of the polishing plate.

26. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 25, wherein the specified length is in the range 5 mm to 50 mm, the first angle is in a range of 2 degrees to 60 degrees, and the second angle is 0 degrees or more, and less than the first angle.

27. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the wet chemical etching is carried out after tension fracture of the light-propagating body by irradiation of carbon dioxide gas laser light, before the step of making the light-propagating body hook-shaped.

28. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the wet chemical etching is carried out after tension fracture of the light-propagating body by irradiation of carbon dioxide gas laser light, and the step of making the light-propagating body hook-shaped.

29. The method of manufacturing a light-propagating probe

for a near-field microscope as disclosed in claim 1, wherein the metal film coating step for forming the transparent opening is a vacuum deposition step using a rotating deposition jig to carry out deposition while rotating the light-propagating body, the rotating deposition jig having a structure where the light-propagating body is held so that the jig rotational axis becomes the same as or parallel to the center axis of the tip section of the light-propagating body that has been sharpened and formed into a hook shape.

30. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the metal film coating step for forming the transparent opening is a step of depositing the metal film coating to a desired film thickness in at least two stages, including a procedure of carrying out deposition a first time, opening a vacuum chamber to the atmosphere, and carrying out deposition a second time.

31. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the metal film coating step for forming the transparent opening is a step of depositing the metal film coating to a desired film thickness in at least two stages, including a procedure of carrying out deposition a first time, stopping exhaust of a vacuum, injecting oxygen gas until a desired pressure is reached, exhausting the vacuum

again and carrying out deposition a second time.

32. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the step for metal film coating spring operating part rearwards from the hook-shaped section is a vacuum deposition step using a rotating deposition jig to carry out deposition while rotating the light-propagating body, the rotating deposition jig having a structure where the light-propagating body is held so that the jig rotational axis becomes the same as or parallel to the center axis of the spring operating part rearward from the hook-shaped section.

33. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the step for metal film coating the spring operating part rearwards from the hook-shaped section is a step of forming a metal film by vacuum deposition or sputtering from at least two directions around the center axis of the spring operating part rearwards from the hook-shaped section, a light-propagating body fixing jig for film formation being constructed so as to easily enable rotation around the center axis of a straight part rearwards from the hook-shaped section.

34. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the

metal film coating is any of aluminum, aluminum silicon alloy, gold or silver.

35. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the metal film coating is a two layer construction of any of silver/gold, chrome/gold, aluminum/gold, aluminum silicon alloy/gold.

36. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 29, wherein the aluminum silicon alloy has a silicon component in a weight ratio of 0.5% to 2%.

37. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the film thickness of the metal film coating is from 30 nm to 1,000 nm.

38. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 29, wherein the vacuum deposition step has a film formation rate is 5 nm per second or faster.

39. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 29, wherein the

vacuum deposition step has a film formation rate in a range of 10 nm to 100 nm per second.

40. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 29, wherein the vacuum deposition step has a rotation rate for the rotating deposition jig in a range from 30 times per second to 1,000 times per second.

41. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the step of protecting the transparent opening with a resist material includes a procedure for dripping trace amounts of the resist material onto a flat plate, and inserting the transparent opening from 5 μm to 200 μm into section of the resist material that is raised up by its own surface tension using a precision stage.

42. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the step of protecting the transparent opening with a resist material determines insertion amount while performing observation using a microscope.

43. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 41, wherein the

resist material is a resin material mainly composed of any of butyl acetate, ethyl acetate, or nitrocellulose.

44. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the step for removing the resist material includes a procedure for ultrasonic cleaning using a cleaning solvent mainly composed of N-methyl-2-pyrrolidone.

45. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1 further including a procedure for removing trace amounts of foreign matter that have become attached to the light-propagating body surface by ultrasonic cleaning using a cleaning solvent mainly composed of N-methyl-2-pyrrolidone, executed before any or all of the step of sharpening the light-propagating probe body, the step of forming the light-propagating probe body in a hook shape, the step of forming the reflecting surface; the metal film coating step for forming the transparent opening section, the step of protecting the transparent opening section with a resist material, the step for metal film coating a spring operating part rearwards from the hook-shaped section, and the step of removing the resist material.

46. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein, with

respect to the step of sharpening the light-propagating probe body, the step of forming the light-propagating probe body in a hook shape, the step of forming the reflecting surface, the metal film coating step for forming the transparent opening section, the step of protecting the transparent opening section with a resist material, the step for metal film coating a spring operating part rearwards from the hook-shaped section, and the step of removing the resist material, handling of the light-propagating body is carried out under an environment using anti-static means.

47. The method of manufacturing a light-propagating probe for a near-field microscope as disclosed in claim 1, wherein the antistatic means using any one of an ionizer, an antistatic sheet, a metal case for light-propagating body storage, or humidity control.